Section 7

Information Used To Determine Emissions

<u>Information Used to Determine Emissions</u> shall include the following:

☐ If manufacturer data are used, include specifications for emissions units <u>and</u> control equipment, including control efficiencies specifications and sufficient engineering data for verification of control equipment operation, including design drawings, test reports, and design parameters that affect normal operation.

☐ If test data are used, include a copy of the complete test report. If the test data are for an emissions unit other than the one being permitted, the emission units must be identical. Test data may not be used if any difference in operating conditions of the unit being permitted and the unit represented in the test report significantly effect emission rates.

☑ If the most current copy of AP-42 is used, reference the section and date located at the bottom of the page. Include a copy of the page containing the emissions factors, and clearly mark the factors used in the calculations.

☑ If an older version of AP-42 is used, include a complete copy of the section.

☑ If an EPA document or other material is referenced, include a complete copy.

☐ Fuel specifications sheet.

☐ If computer models are used to estimate emissions, include an input summary (if available) and a detailed report, and a disk containing the input file(s) used to run the model. For tank-flashing emissions, include a discussion of the method used to estimate tank-flashing emissions, relative thresholds (i.e., permit or major source (NSPS, PSD or Title V)), accuracy of the model, the input and output from simulation models and software, all calculations, documentation of any assumptions used, descriptions of sampling methods and conditions, copies of any lab sample analysis.

A variety of sources were used for calculations and are attached to this section.

- Burner combustion calculations used AP-42 emission factors (AP42 Table 1.6-1)

- Debarker, log cutter, log shaver, wood chipper use green wood. These emission factors were obtained from an older AP-42 document and a Title V Par 71 permit issued by the US EPA to Three Rivers Timber, inc. (see Table 5)
- Haul road emission used AP-42 emission factors for TSP and PM10 (chapter 13.2.2, miscellaneous sources)

- PM2.5 rates were computed as a fraction of PM10 for haul road emissions and used an EPA document (Examination of Multiplier used to Estimate PM2.5fugitive dust emissions from PM10, Thomas G. Pace, US EPA)

- Wood dust is a New Mexico Toxic Air Pollutant (TAP). According to an OSHA document, very little wood dust from green wood is respirable particles and the fraction of PM2.5 is conservatively assumed to be 0.1PM10. (See WHO monographs for wood dust)

Table 1.6-1. EMISSION FACTORS FOR PM FROM WOOD RESIDUE COMBUSTION[a]

Fuel	PM Control Device	Filterable PM Emission Factor (lb/MMbtu)	Filterable PM EMISSION FACTOR RATING	Filterable PM-10[b] Emission Factor (lb/MMbtu)	Filterable PM-10[b] EMISSION FACTOR RATING	Filterable PM-2.5[b] Emission Factor (lb/MMbtu)	Filterable PM-2.5[b] EMISSION FACTOR RATING
Bark/Bark and Wet Wood	No Control[c]	0.56[d]	C	0.50[e]	D	0.43[e]	D
Dry Wood	No Control[c]	0.40[f]	A	0.36[e]	D	0.31[e]	D
Wet Wood	No Control[c]	0.33[g]	A	0.29[e]	D	0.25[e]	D
Bark	Mechanical Collector	0.54[h]	D	0.49[e]	D	0.29[e]	D
Bark and Wet Wood	Mechanical Collector	0.35[i]	C	0.32[e]	D	0.19[e]	D
Dry Wood	Mechanical Collector	0.30[j]	A	0.27[e]	D	0.16[e]	D
Wet Wood	Mechanical Collector	0.22[k]	A	0.20[e]	D	0.12[e]	D
All Fuels[m]	Electrolyzed Gravel Bed	0.1[m]	D	0.074[e]	D	0.065[e]	D
All Fuels[m]	Wet Scrubber	0.066[n]	A	0.065[e]	D	0.065[e]	D
All Fuels[m]	Fabric Filter	0.1[o]	C	0.074[e]	D	0.065[e]	
All Fuels[m]	Electrostatic Precipitator	0.054[p]	B	0.04[e]	D	0.035[e]	
		Condensible PM					
All Fuels[m]	All Controls/No Controls	0.017[q]	A				

brinda@serafinatechnical.com

From: Allman, Martha (EEC) [martha.allman@ky.gov]
Sent: Friday, January 29, 2010 12:32 PM
To: brinda@serafinatechnical.com
Cc: Cathy Tyson-Foster
Subject: RE: wood shavings emissions

Brinda,

The following table contains the emission factors used in the application as it relates to wood operations:

Description		Quantity	Pollutant (CAS #)	Emission Factor (lb/SCC unit)
Name of Unit:	Log shaving Operation	1	PT	0.024
SCC Code:		1	PM-10	0.024
SCC Units:	tons of wood/hour			
Name of Unit:	Wood Shavings/Sawdust Handling	1	PT	2
SCC Code:	30700803	1	PM-10	1
SCC Units:	tons of shavings and sawdust/hour			
Name of Unit:	Baling Operation	1	PT	2
SCC Code:		1	PM-10	1
SCC Units:	tons of shavings/hour			

Here are some other possible sources of information:

http://www.arb.ca.gov/ei/areasrc/ccosmeth/att_k_wood_processing.doc

daq.state.nc.us/monitor/eminv/industry/wood/woodwast.pdf

http://www.npi.gov.au/publications/emission-estimation-technique/ftimber.html

The North Carolina document is focused on wood combustion, so it considers all wood waste from sawing, even those that are too large to be considered PM. I hope this is helpful.

Martha M. Allman, P.E.
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tel: (502) 564-3999 ext. 4465
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From: brinda@serafinatechnical.com [mailto:brinda@serafinatechnical.com]
Sent: Friday, January 29, 2010 1:55 PM
To: Allman, Martha (EEC)
Cc: 'Cathy Tyson-Foster'
Subject: wood shavings emissions

Hi Martha,

I am trying to find out emission factors for soft wood shavings for animal bedding. The facility brings in soft wood - logs, debarks, cuts and then shavings are produced. The shavings are pretty large about 1/16" in thickness and I did not see any emissions during this process. The shavings are transported in covered conveyor to a bin. The wood is 50% moisture content.

Thank you for giving us any emission factors for this type of process that went into your calculations.

Brinda Ramanathan,
Senior Environmental Engineer
Serafina Technical Consulting LLC
www.serafinatechnical.com
Phone 575-421-0124
Cell 505-617-0185

Air Pollution Control Date: August 23, 2002
Title V Permit to Operate
Statement of Basis for Permit No. R10T5-ID-00-02

Three Rivers Timber, Inc.
Nez Perce Reservation
Kamiah, Idaho

1. EPA Authority to Issue Part 71 Permits

On July 1, 1996 (61 FR 34202), EPA adopted regulations codified at 40 CFR Part 71 setting forth the procedures and terms under which the Agency would administer a federal operating permits program. These regulations were updated on February 19, 1999 (64 FR 8247), to incorporate EPA's approach for issuing federal operating permits to covered stationary sources in Indian Country.

As described in 40 CFR 71.4(a), EPA will implement a Part 71 program in areas where a state, local, or Tribal agency has not developed an approved Part 70 program. Unlike states, Indian Tribes are not required to develop operating permits programs, though EPA encourages Tribes to do so. See, for example, Indian Tribes: Air Quality Planning and Management (63 FR 7253, February 12, 1998) (also known as the "Tribal Authority Rule"). Therefore, within Indian Country, EPA will administer and enforce a Part 71 federal operating permits program for stationary sources until Tribes receive approval to administer their own operating permits programs.

2. The Nez Perce Tribe

a. Indian Country: Three Rivers Timber is located within the exterior boundaries of the Nez Perce Reservation and is in Indian Country, as defined in 40 CFR Part 71.

b. The Nez Perce Reservation: In 1855, Governor Stevens concluded a treaty with the Nez Perce recognizing tribal rights to an immense tract of country consisting of some 7.5 million acres. A new treaty in 1863 reduced the reservation to its current size of approximately 760,000 acres located in northern Idaho. Today there are 15 communities located within the boundaries of the reservation. Based on 1986 data, the population is estimated at about 11,400 within the incorporated communities. Another 5,000 to 6,000 people live in the rural areas. Tribal enrollment is approximately 3,300 members with 1,000 members living off the reservation.

c. Tribal Government: The Nez Perce Tribe operates under a constitution that was approved in 1958. The Tribe's constitution provides that a nine member Nez Perce Tribal Executive Committee is the governing body.

Timber is required to certify to the accuracy and completeness of all data submitted to EPA, including the accuracy of its annual emission inventory. If at any time EPA becomes aware of a more accurate way to characterize the emissions from Three Rivers Timber, through information provided by the source or by any other means, these equations and/or emission factors will be revised. It is EPA's expectation that Three Rivers Timber will use these equations and emission factors to calculate their annual emissions and to pay fees unless Three Rivers Timber can justify, in writing, why a different equation or emission factor or other estimation methodology more accurately represents their emissions for the year.

All of the calculations in Tables 5 and 6 rely upon emission factors. Please see the discussion of the uses and limitations of emission factors above under 3(f). Table 7 describes the source of each emission factor used in Tables 5 and 6.

Calculate actual annual emissions, for fee purposes, for emission units 01 through 19 using the following equation and data specified in Table 5 below:

$$E = EF \times AP \times K$$

Where:

E = pollutant emissions in tons/year;

AP = recorded production rate or actual annual throughput for parameter identified in Table 5 in the units specified;

EF = emission factor from Table 5; and,

K = 1 ton/2000 lbs for conversion of actual annual emissions from pounds per year to tons per year.

Table 5

Calculating Actual Annual Emissions for Fee Purposes for Point Sources Emissions Units 01 through 19					
Emissions Unit and Unit ID #	Pollutant	Emission Factor (EF)	Emission Factor Units	Actual Production (AP)	Actual Production Units
Debarker #01	PM10	0.011	lb PM10/ton logs	raw logs processed	tons/year
Debarker #02	PM10	0.011	lb PM10/ton logs	raw logs processed	tons/year
Shavings/Sawdust Bin Loading #03a	PM10	0.23	lb PM10/ton at 50% moisture content	green sawdust from saws transferred to bin	tons/year at 50% moisture content
Shavings/Sawdust Truck Loading #03b	PM10	0.48	lb PM10/ton at 50% moisture content	green sawdust from bin transferred to trucks	tons/year at 50% moisture content

Green Chip Bin #04a	PM10	0.05	lb PM10/bd ton at 0% moisture content	green chips from saws to storage bin	tons/year at 0% moisture content
Green Chip Truck Loading #04b	PM10	0.48	lb PM10/ton at 50% moisture content	green chips from bin transferred to trucks	tons/year at 50% moisture content
Shavings/Sawdust Bin Cyclone #05	PM10	1.1	lbs PM10 per hour	green sawdust from emission unit #03	hours per year of operation
Green Chip Cyclone #06	PM10	0.25	lb PM10/bd ton at 0% moisture content	trim ends/chips from cyclone to shaker	tons/year at 0% moisture content
Cutoff Saw #07	PM10	0.08	lb PM10/ton logs at 55% moisture content	logs cut prior to debarking	tons/year at 55% moisture content
Conveyors #08	PM10	0.011	lb PM10/ton material	material conveyed (mostly green bark)	tons/year
Wood Waste Boiler #10	NOx	0.396	lb NOx/MMBtu	amount of fuel burned in lbs/yr times the Btu value of the fuel (4500 Btu/lb fuel)	MMBtu/yr
	VOC	0.018	lb VOC/MMBtu	amount of fuel burned in lbs/yr times the Btu value of the fuel (4500 Btu/lb fuel)	MMBtu/yr
	SO2	0.022	lb SO2/MMBtu	amount of fuel burned in lbs/yr times the Btu value of the fuel (4500 Btu/lb fuel)	MMBtu/yr
	PM10	0.4	lb PM10/MMBtu	amount of fuel burned in lbs/yr times the Btu value of the fuel (4500 Btu/lb fuel)	MMBtu/yr
Wood Waste Boiler #11	NOx	0.396	lb NOx/MMBtu	amount of fuel burned in lbs/yr times the Btu value of the fuel (4500 Btu/lb fuel)	MMBtu/yr
	VOC	0.018	lb VOC/MMBtu	amount of fuel burned in lbs/yr times the Btu value of the fuel (4500 Btu/lb fuel)	MMBtu/yr
	SO2	0.022	lb SO2/MMBtu	amount of fuel burned in lbs/yr times the Btu value of the fuel (4500 Btu/lb fuel)	MMBtu/yr

Examination of the Multiplier Used to Estimate PM2.5 Fugitive Dust Emissions from PM10

Thompson G. Pace, U. S. EPA

Background and Overview

The major sources of fugitive dust emissions are paved and unpaved roads, construction, agricultural operations, minerals industries and wind erosion from both agricultural and non agricultural lands. Fugitive dust in the ambient air is predominantly comprised of coarse particles (between 10 and 2.5um) and is a relatively minor part of fine PM, i.e., PM2.5. However, the emissions inventory suggests that about one half of primary PM2.5 emissions are from fugitive dust, and these emissions contribute to the overestimation of ambient PM2.5 concentrations by air quality models. This overestimation creates problems for those involved in PM2.5, regional haze and PM Coarse analyses. Most experts agree that this overestimation is due to a combination of shortcomings in the inventory-modeling process: 1) the multiplier used to "scale" or infer PM2.5 from PM10 emissions in the inventory, 2) faulty emission factor algorithms, 3) imprecise or difficult to obtain activity data to apply these algorithms (including inability to account for the effect of actual meteorological conditions on emissions), and 4) modeling deficiencies (especially in the treatment of particles near their point of emissions). A method was developed to improve the treatment of particles near their point of release (Pace 2004)[1]. Also, work is underway in some areas to improve activity data for fugitive dust categories in some areas. The emissions algorithms for paved and unpaved roads were revised within the past few years to incorporate minor improvements. This paper reviews the current data related to the multiplier used to "scale" or infer PM2.5 from PM10 emissions in the inventory.

EPA, States and Tribes develop emission estimates for the fugitive dust categories based on emission factors previously developed for the EPA, mostly by the Midwest Research Institute (MRI). Essentially all of the data that form the basis for EPA's PM10 fugitive dust emission factors were collected by MRI using cascade impactors. There are several hundred test runs for PM10 from paved and unpaved roads, but limited field test data are available for other categories. Algorithms were developed to relate PM10 emissions to certain variables such as road types, surface conditions, moisture and vehicle speed and these are described in AP-42 (US EPA 2005). The algorithms incorporate a set of PM2.5 to PM10 multipliers, or ratios to estimate PM2.5 fugitive dust emissions as a fraction of PM10 emission estimates because there were insufficient data to develop PM2.5 algorithms separately. In fact, there were only 3 test sites (NC, CO & NV) that collected any PM2.5 samples around roads, and other categories have even less data.

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[1] The methodology suggests that it is appropriate to adjust the fraction of dust emissions available for transport away from the vicinity of the source to account for particles removed near the source by land cover and other mechanisms while the plume is very compact and close to the ground. Nationally, this adjustment averages around 50%, but varies locally depending on the land cover. While this method will help provide closure between the modeling and monitored data, the modeled concentrations of crustal matter will still be substantially higher than the measured values until other potential sources of error (such as the PM2.5: PM10 multiplier are addressed.

Issues have been raised regarding potentially significant biases in the PM2.5 cascade impactor measurements made by MRI (US EPA 1981, WRAP 2004). These biases are mainly attributed to carryover of larger particles into the lower and backup stages of the impactors, creating a bias toward fine particles. MRI has tried to address these concerns over the years, primarily by greasing the impaction surfaces, but once a monolayer of particles coats the greased substrate, particle bounce and carryover can reoccur. Thus, the carryover issue remains unresolved and bias is still believed to occur.

Biases have also been attributed to the dichotomous sampler (dichot), an instrument occasionally used to estimate PM2.5 to PM10 ratios. In an ambient sampling study in Phoenix, researchers saw a carryover of coarse mass into the fine fraction due to the cut point inefficiency of the sampler. They estimated the carryover to be 10% of the fine mass in a typical urban setting. In theory, the carryover would be substantially higher than 10% if the sampler had been directly in the plume of a fugitive dust source (Vanderpool 2004). Other researchers have noted that the dichots may have a cut point higher than design especially in dust plumes and under high wind conditions. Also, heavily loaded filters are more likely to lose some of the sample during handling and electrostatic charges may exacerbate particle loss. Since these issues would result in a mix of high and low potential biases to the PM2.5 to PM10 ratio, the real net bias (if any) in dichot-derived ratios is not known.

In 1996, MRI recommended interim revisions to the PM2.5 to PM 10 multipliers for various fugitive dust categories. These interim ratios varied from 0.15 to 0.25 depending on the source category, as shown in Table 1. The MRI recommendations were based on limited supporting data and broad assumptions, as the Table shows. They proposed additional testing and also noted that a review of ambient data may justify further changes to the multipliers (Cowherd and Kuykendal 1996). Note that the grand average multiplier (weighted for emissions) is about 0.17.

Category	Multiplier (PM 2.5 / PM10)	Supporting Data
Wind Erosion (Ag)	0.15	Analogy to industrial wind erosion
Ag Crops	0.20	DRI Dust Resuspension & UCD ~ 0.12 for Harvesting
Ag Livestock	0.15	No Data
Wind Erosion (non Ag)	0.25	Reduced from MRI wind tunnel result of .40 (felt biased)
Construction	0.15	Construction dominated by unpaved roads
Paved Roads	0.25	Reduced 0.46 to 0.25 assuming 1/2 is exhaust
Unpaved Roads	0.15	AZDEQ Dichot test (0.25), NAPAP/Ill Water Survey (0.10) & Pedco/MRI dichot data at coal mines (0.15)

Table 1. Interim multipliers to estimate PM2.5 from PM10 in the NEI (Cowherd and Kuykendal 1996)

While the interim particle size adjustment factors generally represented a substantial downward adjustment of AP-42 particle size multipliers, many concerns still exist about the apparent overestimation of PM2.5 emissions and the validity of the ratios. This paper summarizes a growing body of scientific evidence indicating that the interim multipliers still overestimate the PM2.5 to PM 10 ratio. For example, there are several issues related to the basis for the recommendations in Table 1 that warrant further review and there are several new sets of source-oriented measurements to consider. Also, the body of ambient data presents a compelling case that the fugitive dust-modeling systems as typically applied do substantially overestimate crustal material. None of this new insight relies on the old cascade impactor data that was initially used to develop the multipliers. An ongoing testing program sponsored by the Western Regional Air Partnership (WRAP) will provide additional information on this bias (WRAP 2004).

PM2.5:PM10 Multiplier for Paved Roads
In 2003, the US EPA revised the AP-42 Section for Paved Roads based in part on MRI tests conducted in 1997 in three cities (US EPA 1997 and 2003). These tests did not originally correct for the presence of tailpipe exhaust within the dust plume (Cowherd and Kuykendal 2004). In the 2003 revision, corrections for vehicle exhaust; tire and brake wear are estimated and incorporated into the algorithms. The net result of the 2003 revision is that paved road fugitive dust emissions are very small for interstates, freeways and major arterials in the 2002 NEI. However, the minor arterials, collectors and local roads collectively emit almost 300,000 TPY of PM2.5 nationally and the PM2.5 to PM10 multiplier ratio is 0.2. This multiplier is based in part on cascade impactor results.

Transportation Research Board (TRB) / National Research Council Field Study – This study analyzed ambient samples taken near eight paved roadway locations (predominantly minor arterials, collectors and local streets) using source apportionment. The results show that fugitive dust comprised only 27% on average of the PM2.5 mass measured adjacent to these roadways. The remainder was from exhaust, brake and tire wear. More important, the average ratio of PM2.5 fugitive dust to PM10 fugitive dust emitted from these test roads was 0.1, considerably lower than the ratio 0.2 for minor arterials, collectors and local roads recommended in the 2003 revision to AP-42. (Transportation Research Board, 2003).

Dust Traker Tests in Idaho – The Desert Research Institute (DRI) used the Dust Traker in Treasure Valley, Idaho to estimate PM10 and PM2.5 emissions from paved and unpaved roads. In this study, they measured both PM2.5 and PM10 and found the PM2.5: PM10 ratio to be 0.06 for both paved and unpaved roads (Kuhns 2002).

Emissions Measurements on a Paved Road Outside a Construction Site Entrance - MRI measured emissions from a paved road located just outside of a construction site in Kansas City under contract to the US EPA (Muleski 2003). In this study, the PM2.5 to PM10 ratio was only 0.03. The EPA Project Manager believes that the lower ratio found in this study is attributable at least in part to use in this study of a new design hybrid sampler instead of the high volume cascade impactor that MRI has customarily used (Kinsey 2004). When the two devices were collocated in a road dust plume during preliminary testing, the PM2.5 concentration measured by the hybrid sampler was a factor of ~ 3 lower than that measured by the impactor.

PM Multiplier for Unpaved Roads

Clarification of Original PEDCo/MRI Surface Coal Mining Report - In Table 1 above, MRI relied in part on PEDCo/MRI upwind-downwind source testing using the dichotomous sampler as a basis for the unpaved road recommendation (US EPA 1981). They cited a PM2.5: PM10 ratio of 0.15 for light and medium duty vehicles on unpaved roads in that study. This value was cited in Cowherd and Kuykendal (1996). However, in a subsequent EPA report PEDCo re-analyzed the joint MRI/PEDCo study data for PM2.5, PM10 and PM15and found that the ratio of PM2.5 to PM10 was actually 0.10 (U.S. EPA 1983). Thus, the ratio 0.15 cited by Cowherd and Kuykendal in 1996 appears to be based on an error that was corrected in a subsequent report.

Unpaved Roads (and Earthmoving) at a Wyoming Surface Coal Mine - AP-42 Section 11.9 was revised in October 1998, based on new testing at a mine in Wyoming. This report contains results of testing conducted on unpaved roads and grader and scraper operations for PM15 and PM2.5. Based on this data and the ratio of PM10 to PM15 determined in the PEDCo study, the average ratio of PM2.5 to PM10 was 0.12 for light and medium duty vehicles and 0.04 to 0.08 for scrapers and graders respectively (U.S. EPA 1998).

Midwest Research Institute (MRI) Testing in 3 Cities – This testing was done in Denver, Reno and Raleigh by MRI and they collected data using both Cascade impactors and dichotomous samplers. In it, the average ratio using the impactor was 0.25, while the ratio using collocated source-oriented dichotomous samplers was 0.07. The report cites issues with both dichot and impactors (US EPA 1997).

Miscellaneous References - In 1988, Allen Williams at the Illinois Water Survey evaluated dichot tests near unpaved roads and determined the PM2.5 to PM10 ratio to be 0.10 (Williams 1988). As stated previously, the Dust Tracker tests in Idaho used a ratio multiplier of 0.06 for both unpaved and paved roads (Kuhns 2002). Also, the Arizona DEQ studied fugitive dust around unpaved roads and found the PM2.5 to PM10 ratio to be 0.25 (AZ DEQ 1990). The AZ DEQ data point seems to be an outlier and its importance is diminished because the report could not be located to verify the reference contained in MRI's interim recommendations.

PM2.5 Multiplier for Construction, Agricultural Operations and Windblown Dust

In the interim recommendations, MRI used the same data to support unpaved roads and construction, posing construction activities are dominated by unpaved road emissions. As noted above, the Wyoming surface coal mining study reported average ratio of PM2.5 to PM10 was 0.12 for light and medium duty vehicles and 0.04 to 0.8 for scrapers and graders respectively (U.S. EPA 1998). The scraper and grader operations for removal of overburden at mines are very similar to construction-related earthmoving. In tests of agricultural field dust in CA, Lowell Ashbaugh reported the ratio of PM2.5 to PM10 to be 0.12 (Ashbaugh 2004). The Great Basins AQCD has conducted extensive source-oriented particle measurements in Keeler, CA on the edge of Owens Lake. At this site, dominated by windblown dust from the dry lake bed, they found the ratio of PM2.5 to PM10 to be "around or less than 0.10" (Ono, 2004).

PM2.5 Multiplier – Indications from Ambient Observations and Other Information
IMPROVE Ambient Network - The Interagency Monitoring of Protected Visual Environments (IMPROVE) program "reconstructs" the soil component of PM2.5 at each site based on the abundance of soil-related elements at each site. It also measures coarse mass and some researchers assume this to be essentially all soil. However, in practice, the coarse mass contains some limited amounts of nitrate and other non-soil compounds. Using data from IMPROVE for 1999-2002, the ratio of fine soil to total soil (fine soil + coarse mass) was calculated to be 0.11 (IMPROVE 2004). This could be low due the presence of other species in small amounts in the coarse fraction, but conservatively, the fine soil to coarse soil ratio is not likely to be higher than 0.12.

Ambient Trace Elements in the San Joaquin Valley (SJV) - In 2003, Richard Countess estimated the PM2.5/PM10 ratio based on SJV ambient measurements of trace elements. The average ratio for aluminum and silicon was 0.05; for calcium, titanium and iron the ratio ranged from 0.10 to 0.16. Countess estimated that a species-weighted ratio would be 0.06, based on the relative abundances of these elements in fugitive dust (Countess 2003). This suggests that the ratio of fugitive dust in the PM2.5 size fraction relative to the PM10 size fraction (based on ambient measurements in the San Joaquin Valley) is approximately one-third of 0.17 the emissions-weighted multiplier in Table 1.

Resuspended Soil Samples - Researchers in the San Joaquin Valley collected bulk samples of dust from a number of sources in the area. The samples were resuspended in a special recirculation chamber where a cyclone sampler measured the potential of the soil samples to emit dust in the PM2.5 and PM10 size ranges. The relationship of PM2.5 and PM10 emission potential was well correlated over a range of soil types ($R^2 = 0.94$, PM2.5 = .09 *PM10 + 0.13) suggesting that PM2.5/PM10 is close to 0.10 or 10% (Carvacho 2002). As noted above, sampler bias, if any could introduce errors in the above analyses.

Researchers at the Desert Research Institute also resuspended soil samples in their laboratory in 1986. This testing resulted in the following ratio data: paved roads, 0.2; unpaved roads 0.15; agricultural soil 0.2; and sand/gravel 0.4. However, the dust resuspension chamber used by DRI didn't recirculate the airflow to maintain a uniform size distribution throughout the sample collection process and the ratios are believed to be biased high (Etyemezian 2004).

The indications from ambient measurements and resuspension chambers could be subject to a range of errors and bias. For example, ambient ratio of PM2.5: PM10 would reflect any and all processes that act on the particle size distribution during transport from the sources to the ambient monitors and the ratio would be affected by sampler or analytical bias, if any. There could also be errors in the PM2.5: PM10 emissions multipliers. When viewed in context of these caveats the data do seem to support a lower ratio of PM2.5: PM10

Summary

A number of source-oriented measurements of PM2.5 and PM10 have been reported since the 1996 work by Cowherd and Kuykendal. These have been discussed above and are briefly summarized below. Also, ambient measurements and other indications of the PM2.5 and PM10 size fractions are summarized.

Paved roads - The PM2.5 to PM10 ratio in the TRB study was 0.10, averaged across eight sites in 2 cities. Dust tracker tests in Idaho averaged 0.06 and at a dirty construction site entrance, the ratio averaged only 0.03. Overall, the ratio ranged from 0.03 to 0.10 although the TRB study (0.10) is the deemed the most representative of typical road conditions nationally. A site-weighted average of these paved road data is 0.09.

Unpaved roads - The rework of the 1981 surface coal mining study dichot data (by PEDCo) suggests a ratio of 0.10 while the more recent study in Wyoming resulted in a ratio of 0.12 for unpaved roads. The Illinois Water Survey tests also indicated an average ratio of 0.10. Overall, the range of the PEDCO and Illinois measurements is 0.10 to 0.12.

Construction, agriculture and windblown dust - These categories don't have an abundance of data on which to base a multiplier. The midpoint of the surface mining grader/scraper operations (assumed similar to construction operations) is 0.08. Agricultural operations are reportedly 0.12 based on only San Joaquin Valley testing. The Owens Lake ratio is 0.10 for windblown dust. A fairly consistent midpoint value for these categories is 0.1.

Ambient Data and other Indicators - The PM2.5: PM10 ratio for ambient samples at IMPROVE sites averaged 0.11 and in the SJV the average was 0.06. The average ratio for soil samples in the SJV was 0.1. Dust sampling in an air recirculation chamber also yielded a ratio of about 0.10. Overall, these data support a ratio of between 0.6 and 0.11 with a mid-point around 0.1.

Table 2 summarizes this review of the PM2.5 to PM10 source-oriented and ambient measurements. The new data and reanalysis of the old data seem to converge around a multiplier of 0.1, or 10%, when averaged across all source categories. Thus, the newly acquired information consistently supports a lower multiplier than is currently in use. However, recommendation of a specific value for the multiplier should await the results of the testing that is being done for the WRAP Fugitive Dust Forum (WRAP 2004). These results are expected in late spring, 2005. It is suggested that once this test report is available, all the available data be considered collectively and a consensus multiplier be developed. Ideally, this consensus would be developed through the collaborative efforts of the researchers that have been studying fugitive dust and the relationship among the size fractions.

Fugitive Dust Category	Current Multiplier	Range of New Data	Midpoint of New Data
Paved Road Tests (All)	**0.2** for lower traffic roads;	**0.03 to 0.10**	**0.09** for lower traffic roads;
Unpaved Road Tests (Public and Industrial)	**0.15**	**0.10 to 0.12**	**0.11**
Other Category Tests (Construction. Agricultural Operations and Windblown Dust)	**0.15 to 0.20**	**0.06 to 0.12**	**0.1**
General Indications Based on Ambient Measurements and Other Tests	**0.15 to 0.25**	**0.06 to 0.11**	**0.1**

Table 2. Data Related to the PM2.5 to PM10 Size Multipliers for use in NEI

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The following empirical expressions may be used to estimate the quantity in pounds (lb) of size-specific particulate emissions from an unpaved road, per vehicle mile traveled (VMT):

For vehicles traveling on unpaved surfaces at industrial sites, emissions are estimated from the following equation:

$$\boxed{E = k\,(s/12)^{a}(W/3)^{b}} \qquad \text{(1a)}$$

and, for vehicles traveling on publicly accessible roads, dominated by light duty vehicles, emissions may be estimated from the following:

$$E = \frac{k\,(s/12)^{a}(S/30)^{d}}{(M/0.5)^{c}} - C \qquad \text{(1b)}$$

where k, a, b, c and d are empirical constants (Reference 6) given below and

- E = size-specific emission factor (lb/VMT)
- s = surface material silt content (%)
- W = mean vehicle weight (tons)
- M = surface material moisture content (%)
- S = mean vehicle speed (mph)
- C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.

The source characteristics s, W and M are referred to as correction parameters for adjusting the emission estimates to local conditions. The metric conversion from lb/VMT to grams (g) per vehicle kilometer traveled (VKT) is as follows:

1 lb/VMT = 281.9 g/VKT

The constants for Equations 1a and 1b based on the stated aerodynamic particle sizes are shown in Tables 13.2.2-2 and 13.2.2-4. The PM-2.5 particle size multipliers (k-factors) are taken from Reference 27.

Table 13.2.2-2. CONSTANTS FOR EQUATIONS 1a AND 1b

Constant	Industrial Roads (Equation 1a)			Public Roads (Equation 1b)		
	PM-2.5	PM-10	PM-30*	PM-2.5	PM-10	PM-30*
k (lb/VMT)	0.15	1.5	4.9	0.18	1.8	6.0
a	0.9	0.9	0.7	1	1	1
b	0.45	0.45	0.45	-	-	-
c	-	-	-	0.2	0.2	0.3
d	-	-	-	0.5	0.5	0.3
Quality Rating	B	B	B	B	B	B

*Assumed equivalent to total suspended particulate matter (TSP)
"-" = not used in the emission factor equation

Table 13.2.2-2 also contains the quality ratings for the various size-specific versions of Equation 1a and 1b. The equation retains the assigned quality rating, if applied within the ranges of source conditions, shown in Table 13.2.2-3, that were tested in developing the equation:

Table 13.2.2-3. RANGE OF SOURCE CONDITIONS USED IN DEVELOPING EQUATION 1a AND 1b

Emission Factor	Surface Silt Content, %	Mean Vehicle Weight		Mean Vehicle Speed		Mean No. of Wheels	Surface Moisture Content, %
		Mg	ton	km/hr	mph		
Industrial Roads (Equation 1a)	1.8-25.2	1.8-260	2-290	8-69	5-43	4-17[a]	0.03-13
Public Roads (Equation 1b)	1.8-35	1.4-2.7	1.5-3	16-88	10-55	4-4.8	0.03-13

[a] See discussion in text.

As noted earlier, the models presented as Equations 1a and 1b were developed from tests of traffic on unpaved surfaces. Unpaved roads have a hard, generally nonporous surface that usually dries quickly after a rainfall or watering, because of traffic-enhanced natural evaporation. (Factors influencing how fast a road dries are discussed in Section 13.2.2.3, below.) The quality ratings given above pertain to the mid-range of the measured source conditions for the equation. A higher mean vehicle weight and a higher than normal traffic rate may be justified when performing a worst-case analysis of emissions from unpaved roads.

The emission factors for the exhaust, brake wear and tire wear of a 1980's vehicle fleet (*C*) was obtained from EPA's MOBILE6.2 model [23]. The emission factor also varies with aerodynamic size range

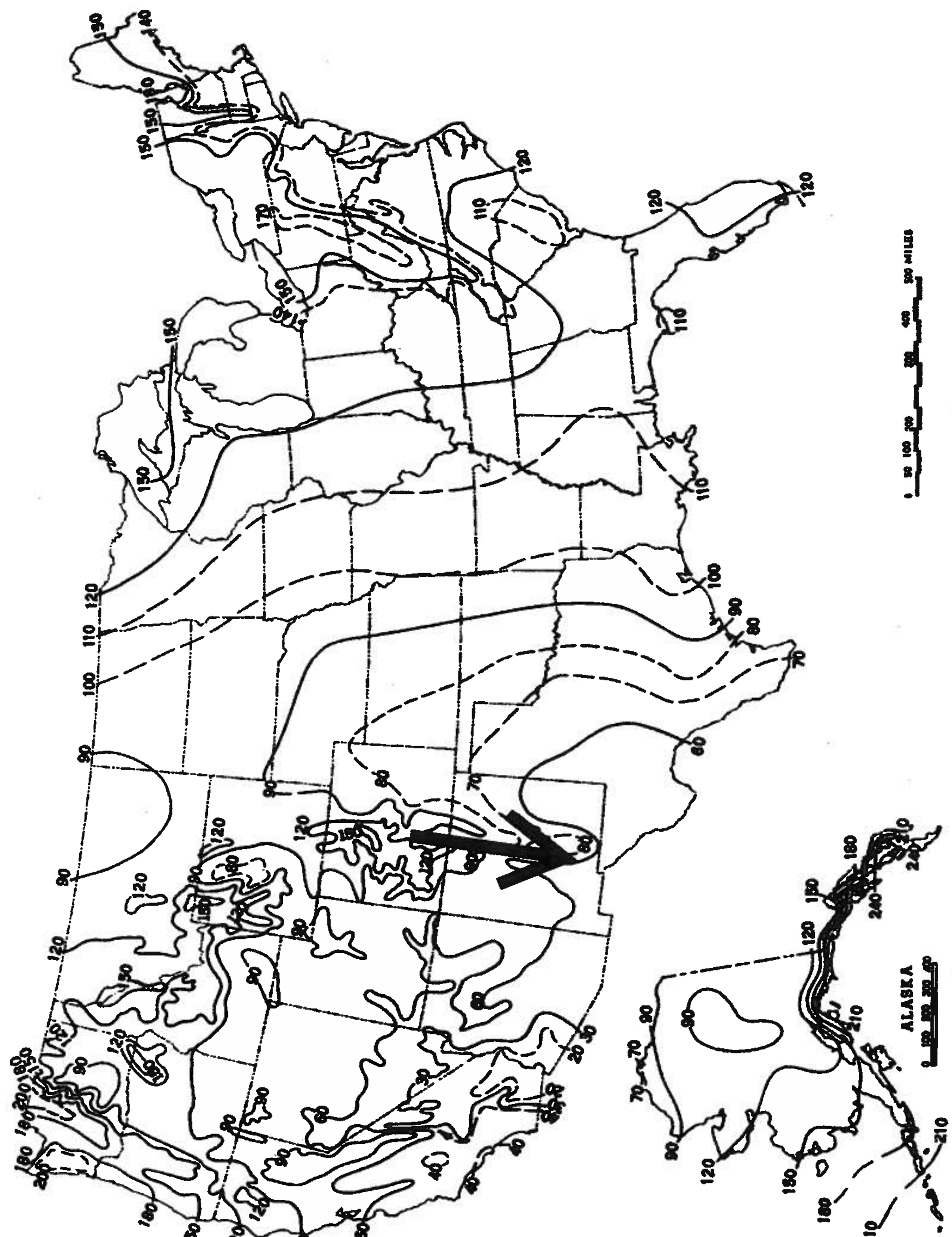

Figure 13.2.2-1. Mean number of days with 0.01 inch or more of precipitation in United States.

WORLD HEALTH ORGANIZATION

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IARC Monographs on the Evaluation of Carcinogenic Risks to Humans

Volume 62
Wood Dust and Formaldehyde

Summary of Data Reported and Evaluation

Last Updated 08/13/97

WOOD DUST
(Group 1)

For definition of Groups, see Preamble Evaluation.

VOL.: 62 (1995) (p. 35)

5. Summary of Data Reported and Evaluation

5.1 Exposure data

Wood is one of the world's most important renewable resources. At least 1700 million m^3 are harvested for industrial use each year. Wood dust, generated in the processing of wood for a wide range of uses, is a complex substance. Its composition varies considerably according to species of tree. Wood dust is composed mainly of cellulose, polyoses and lignin and a large and variable number of substances of lower relative molecular mass which may significantly affect the properties of the wood. These include non-polar organic extractives (fatty acids, resin acids, waxes, alcohols, terpenes, sterols, steryl esters and glycerols), polar organic extractives (tannins, flavonoids, quinones and lignans) and water-soluble extractives (carbohydrates, alkaloids, proteins and inorganic material).

Trees are characterized botanically as gymnosperms (principally conifers, generally referred to as softwoods) and angiosperms (principally deciduous trees, generally referred to as hardwoods). Roughly two-thirds of the wood used commercially worldwide belongs to the group of softwoods. Hardwoods tend to be somewhat more dense and have a higher content of polar extractives than softwoods.

It is estimated that at least two million people are routinely exposed occupationally to wood dust worldwide. Nonoccupational exposure also occurs. The highest exposures have generally been reported in wood furniture and cabinet manufacture, especially during machine sanding and similar operations (with wood dust levels frequently above 5 mg/m^3). Exposure levels above 1 mg/m^3 have also been measured in the finishing departments of plywood and particle-board mills, where wood is sawn and sanded, and in the workroom air of sawmills and planer mills near chippers, saws and planers. Exposure to wood dust also occurs among workers in joinery shops, window and door manufacture, wooden boat manufacture, installation and refinishing of wood floors, pattern and model making, pulp and paper manufacture, construction carpentry and logging. Measurements are generally available only since the 1970s, and exposures may have been higher in the past because of less efficient (or non-existent) local exhaust ventilation and other measures to control dust.

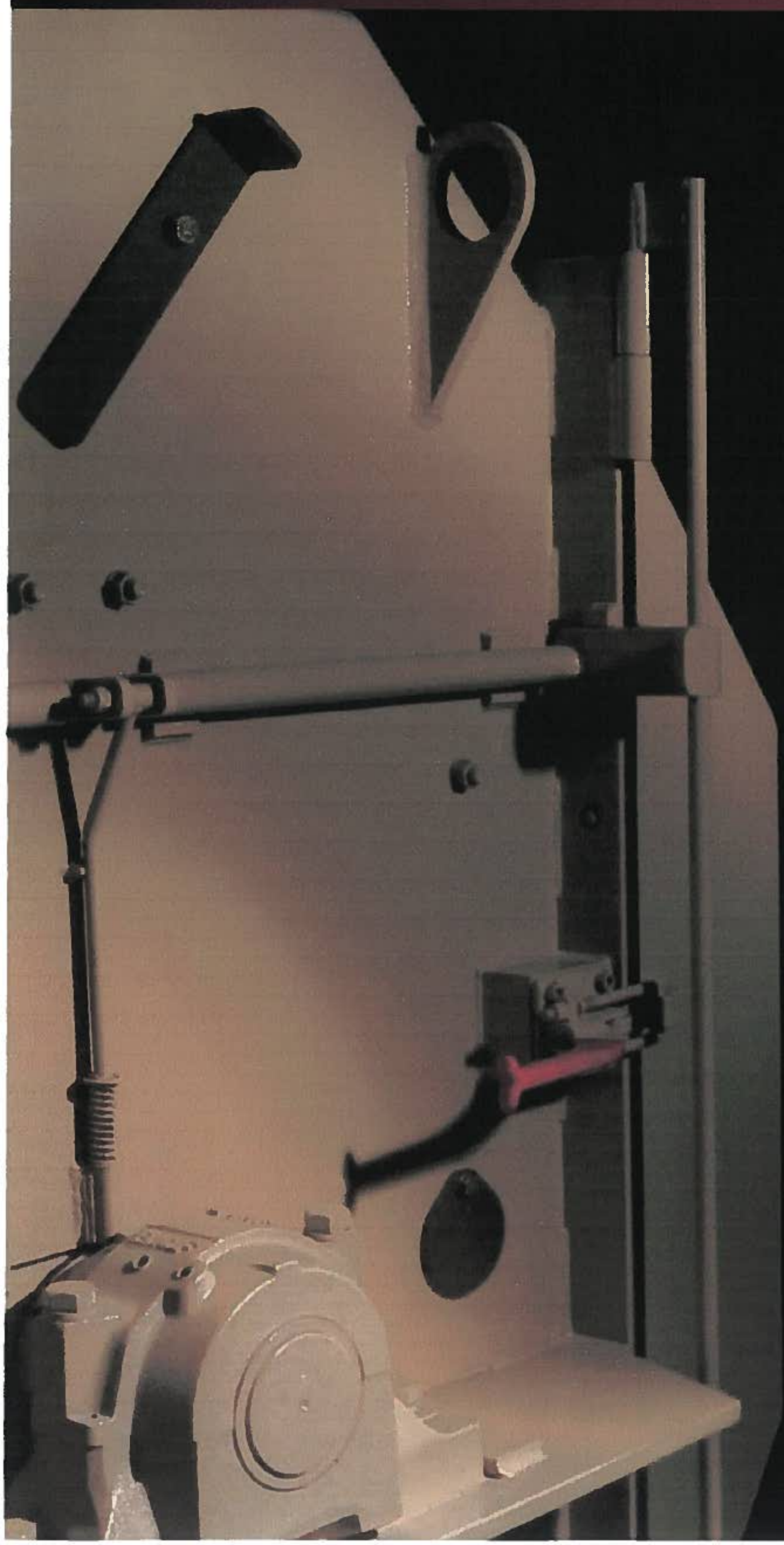
The wood species used in wood-related industries vary greatly by region and by type of product. Both hardwoods and softwoods (either domestically grown or imported) are used in furniture manufacture. Logging, sawmills and plywood and particle-board manufacture generally involve use of trees grown locally. Most of the wood dust (by mass) found in work environments has a mean aerodynamic diameter of more than 5 μ. Some investigators have reported that the dust generated in operations such as sanding and during the processing of hardwoods results in a higher proportion of smaller particle sizes, but the evidence is not consistent.

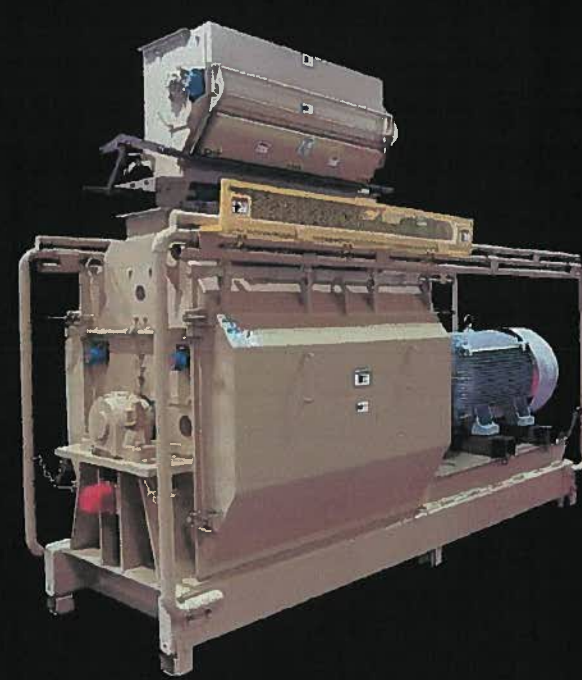
Within the furniture manufacturing industry, exposure may occur to solvents and formaldehyde in glues and surface coatings. Such exposures are usually greatest for workers with low or negligible exposure to wood dust and are infrequent or low for workers with high exposure to wood dust. The manufacture of plywood and particle-board may entail exposure to formaldehyde, solvents, phenol, wood preservatives and engine exhausts. Sawmill workers may also be exposed to wood preservatives and fungal spores. Exposures to chemicals in industries where other wood products are manufactured vary but are in many cases similar to those in the furniture manufacturing industry.

5.2 Human carcinogenicity data

ELIMINATOR

HAMMERMILL





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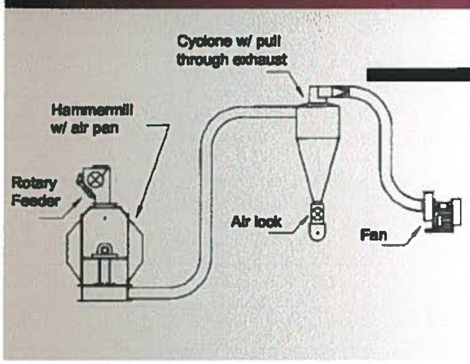
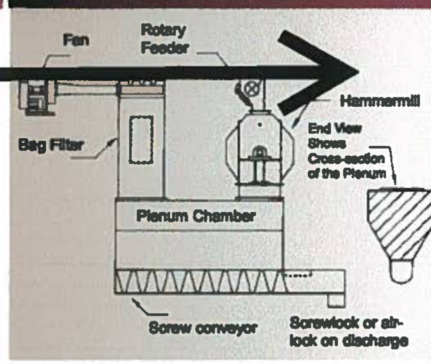
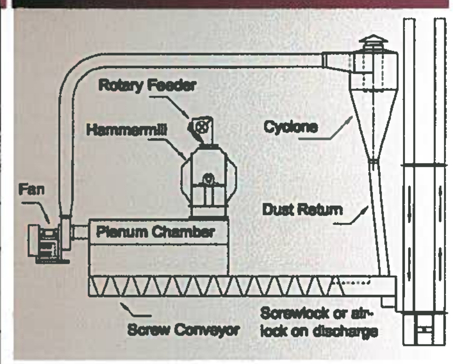


Air Relief Assist w/ Bag Filter



Air Relief Assist w/ Cyclone Separator



HAMMERMILL SPECIFICATIONS

Domestic 60 Cycle Applications

Diameter	RPM	Tip Speed (FPM)	H.P.	Screen Area (sq.in.)
19"	3600	17907	5 - 100	312 - 1152
22"	3600	20735	15 - 150	513 - 1620
26"	1800	12252	15 - 150	608 - 1920
38"	1800	17907	25 - 500	950 - 6000
44"	1800	20735	40 - 600	1140 - 7200
52"	1200	16336	60 - 600	1656 - 6912

International 60 Cycle Applications

Diameter	RPM	Tip Speed (M/SEC)	H.P./KW	Screen Area (sq.cm.)
19"	3600	91	5 - 100	2013 - 7432
22"	3600	105	15 - 150	3310 - 10452
26"	1800	62	15 - 150	3677 - 11613
38"	1800	91	25 - 500	6129 - 38710
44"	1800	105	40 - 600	7355 - 46452
52'	1200	83	60 - 500	10684 - 44594

Industrial Applications - 24 hours/day

Diameter	RPM	Tip Speed (FPM)	H.P.	Screen Area (sq.in.)
19"	3600	17907	10 - 50	576
22"	3000/36000	17279/20735	15 - 150	513 - 1620
38"	1800	17907	25 - 500	950 - 6000
44"	1500-1800	17279/20735	40 - 600	1140 - 7200
52"	1500	20420	60 - 600	1656 - 6912

International 50 Cycle Applications

Diameter	RPM	Tip Speed (M/SEC)	H.P./KW	Screen Area (sq.cm.)
22"	3000	88	15-150/11 - 112	3310 - 10452
26"	3000	104	15-150/11 - 112	3677 - 11613
38"	1500	76	25-500/20 - 375	6129 - 38710
44"	1500	88	40-600/30 - 447	7355 - 46452
52"	1500	104	60-600/45 - 447	10684 - 44594

•Specifications are subject to change without obligation or notice.

WARNING LABELS
"Industry Standard" Safety Warning Labels are applied as recommended and prepared by the AFIA Equipment Manufacturers Council.

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BAC 22809/3/01

Printed in U.S.A.